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91-05714/

Final Report

ERDA 2.1-19

The Completion of a Computer System for Measuring the Shape, Angularity and Size of Cattle

Funded by
The Agriculture Development Fund

FINAL REPORT

"Canada/Saskatchewan ERDA Agreement - Project 2.1 - 19"
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The Completion of a Computer Based System for Measuring the Shape, Angularity and Size of Cattle

a. Executive Summary:

1. A system has been developed that will measure the shape, angularity and size of cattle. The measurements are calculated by a computer program that uses information transferred from a photograph to the computer by means of a digitizing tablet. The system is referred to as the conformation determination system or CDS for short.

   CDS has been tested in the laboratory and found to be accurate to approximately 1.5%. Tests carried out on the living animals proved to be successful. However, greater accuracy/reliability and range of uses will result from modification to the program. Nevertheless, the CDS is already sufficiently useful and flexible to have been employed in several research projects.

2. (Lay Summary)

   The Conformational Determination System "CDS"

   The conformation of cattle has been traditionally judged by eye. Opinion, personal bias and esthetic evaluation have all gone into producing the shape of modern purebred cattle. Unfortunately, human judgment is not always consistent nor is it always based on 'functional efficiency'. Breeding for straight legs, for example, increases the risk of arthritis and other diseases while selection for size may tend to identify 'monsters'. In recent years commercial beef breeders in Saskatchewan have expressed concern that so many replacement bulls are rejected for 'feet and legs'. The purpose of the project that is being described here has been to learn more about conformation and to develop a method by which it may be accurately measured.

   Apart from the health aspects of conformation there are a number of research workers who have demonstrated a link between certain traits of conformation and good production characteristics. However, a major problem in measuring conformation has been that there is no agreement about the descriptions of the points on animal being used in measurement. To give one example. 'Hip height' has nothing to do with the true hip joint. Most workers regard the hip height as the distance from the ground to the hock bone, but the bottom of the hook bone is two or three inches from the top. The ideal measurement is "loin height" but very few workers are consistent and the measurement is not comparable between animals. Therefore, a part of the present study has been to locate the anatomical points most suited to accurate measurement and define these points in simple terms.

   Measuring cattle with a tape and a measuring stick may seem to be an accurate system but we have discovered that two people measuring the same animal sometimes get results that are quite different. A tape running from the pin to the

shoulder must go around the contours of the belly which distorts the real measurement.

There have been attempts to use photographs to measure conformation but the camera also distorts measurements. However, it is possible to program a computer to correct these distortions. This has formed the core of our work. The program that has been developed is called the 'Conformation Determination Stem' or CDS for short. Using CDS is not difficult. Firstly, the subject is marked with washable paint which is placed over the anatomical points that we have defined. Then a photograph is taken with an ordinary 35 mm camera and the resulting slide projected onto a digitizing tablet. This is a device that allows the paint marks on the photograph to be collected by the computer and produce a whole series of measurements. The nice thing about the program is that it also measures the angles of joints which are almost impossible to measure by hand. Another useful feature of the system is that it can be used on wild young animals in a chute complex.

Naturally when animals move or won't hold the same posture for any length of time inaccuracies will occur. The simple solution is to take several photographs of difficult animals and the computer program will now automatically take an average of the measurements produced from each photograph. Another feature of CDS is that it automatically averages the entries for all animals of the same age, breed and sex. In this way it is possible for a producer to compare one his animals with the average. This function has the potential for allowing a producer to select for traits that he might wish to emphasize or suppress. Another refinement that has been added to the program is the capability of measuring change between any two examination dates. In other words CDS can measure growth.

Although CDS provides information that is at least as accurate as is available by manual measurement it is a system that for the time being will be used mostly by research workers. There is considerable interest in conformation amongst commercial producers but handling cattle to obtain the information is labor intensive. Although photographs can be collected in seven minutes from a docile animal it will take much longer if the animal is wild. Unfortunately, some breeders of pedigree animals shy away from a system that might demonstrate weaknesses that would be incompatible with the standards established in the show ring. Functional efficiency means, calving ease, longevity and productivity.

CDS can be used by research workers to measure the angles and dimensions of the pelvis and these findings could be correlated to on going work with calving ease. Many producers are unaware that the size of the claws is extremely variable in some breeds and that straight legs combined with small feet and high body weight could probably be associated with foot unsoundness. There are also many theories that can now be tested accurately that relate conformation traits to high average daily weight gain or high milk production.

The conformation determination system is complete, it works and it is accurate. Using the system in the field will provide information about conformation. The system can be made much more convenient to use for example by substituting a domestic TV camera for the 35 mm system. The system can yield much more information by adding new measurements or features such as udder or rump

volume. This must be in the future, for the time being the industry needs time to adjust to the fact that conformation can be measured and evaluated accurately.

b. Technical Report:

Abstract

A system for objectively measuring bovine conformation accurately has been developed. The conformation determination system - CDS require certain anatomical points to be marked on an animal which is then photographed. The photograph is projected onto a digitizing tablet and the marked points identified and entered in to computer. The CDS program then calculates body and bone measurements as well as the angles of joints. This information can be issued as a report on an individual animal, or as a comparison of two examinations in order to calculate body growth. An average for each measurement is calculated for each dimension or angle for each breed, sex and age accuracy being dependent upon the number of entries made.

Objectives

To develop a 'conformation determination system', CDS that will employ a microcomputer to calculate the distance between defined anatomical points and joint angles of the bovine limb, body and claw using input from a 35 mm transparency.

Background

Selecting cattle for conformation traits by "eyeballing" an animal is a historically established tradition that forms the basis of judging cattle in the show ring. Unfortunately, the system is unreliable because repeatability is inconsistent between judges. Manual measurements can be made with a tape and measuring stick. However, even these simple procedures are unreliable between different workers. Measuring important joint angles is virtually impossible under field conditions. To make matters worse there is no system that has been agreed amongst scientists for defining the points to an from which body measurements should be made. At best it can be said that the basis for evaluating conformation is shaky.

The rationale for seeking to influence changes in conformation appears to be based on opinion. This opinion is sometimes in defiance of informed scientific opinion. As a result the side effects of some breeding trends in the beef industry may ultimately result in the development of sub-lethal characteristics. A good example would be selection for straight hind limbs which is correlated to a high occurrence of degenerative arthritis. Selection for size may also run the risk of selecting for 'monsters'.

It is apparent that a need does exist for a scientific basis for evaluating conformation objectively and this need has motivated the work that is the subject of this report.

Experimental Methods

The first phase in developing the system was to establish that it was in fact feasible to use photographic information that could be converted mathematically to data from which a microcomputer could produce usable measurements. The results exceeded expectations. In laboratory tests using the skeleton of a cow it was found that, on

average, there was a difference of approximately 1.5% between the system measurement and measurements taken manually with a tape measure. We later discovered that manual measurements can differ by more than 1.5% during repeatability trials. For all practical purposes CDS can be regarded as a technically accurate system.

Once the feasibility study was completed the next stage involved creating menu and entry screens that would simplify the entry of information. This developmental work continued almost until the end of the project. Not only was it necessary to enter information about each animal examined but also to capable of comparing measurements at one age with those at another. The measurement of growth was therefore possible. The CDS program was next programmed to have the capability of averaging all the entries for each sex, breed and age for all seventeen hoof and body measurements calculated.

Immediately CDS was proven to be a workable system trials were conducted using ROP bulls and dairy cows. Measuring a young wild bull with a tape measure and measuring stick can be quite difficult and dangerous to the operator. Measuring joint angles is virtually impossible. CDS worked well with the majority of the bulls but a few fought the confinement of the chute complex and could not be confined in acceptable stance. Accuracy was improved by taking several photographs. Despite the difficulties interesting and usable tables of average measurements were developed from these trials.

As the CDS program grew in size it became slower in operation. For this reason the entire program was rewritten in C language which speeds up processing and has the advantage of making the system completely free of commercial copy right. The system code is now stored on twenty-one standard diskettes.

The stage was eventually reached when the system was sufficiently flexible to be shared with other workers. In particular Dr. Ben McDaniel, Department of Animal Science, University of North Carolina has conducted an independent evaluation in collaboration with Dr. H.A.M. te Plate. Dr. McDaniel is one of the most preeminent research workers in the field of bovine conformation and his endorsement of the program has been extremely important. Dr. J.J. Vermunt successfully used the system to study the claw characteristics of dairy heifers and produced valuable information. John McKinnon used the system in a Ph.D. research project in order to monitor growth in height during feeding trials.

The final element of testing has involved an evaluation of human error. Ten veterinary students were used in these tests. Each student marked and measured the same cow ten times. We were able to conclude that one operator was able to repeat the results obtained with reasonable consistency.

Results and Discussion

A. Software Development

Software development has proceeded along three distinct paths: functional capabilities, flexibility and ease of use.

1. **Functional Capabilities**

a. Heart Girth

The heart girth of an animal can now be interpolated from the body weight using a table of empirical values. This calculation provides the potential for CDS to calculate the chest capability of an animal.

b. Surface Area

The area of any closed two dimensional region can now be calculated by the Surface Area Module which has been created in CDS.

The first specific application is the measurement of the area of the sole which has been created and incorporated into CDS.

Other applications of the Surface Area Module which could potentially be incorporated later include:

i. the rump size as an area or estimated volume using the hook width,
ii. the surface area of the abdominal region and
iii. the udder capacity

c. Growth Report

Conformation data stored in the database can be used to generate a Growth Report for an animal. The Growth Report uses data from two exam dates (photo records) and generates a report that has 7 columns of data values for each of the 19 body conformation measurements and the 9 hoof conformation entities. (See Figure 1 for a sample Growth Report).

The 7 columns generated for each conformational entity are:

1. Conformation Entity Name
2. Exam 1 value
3. Average value for animals the same age as Exam 1
4. Exam 2 value
5. Average value for animals the same age as Exam 2
6. Difference between Exam 1 value and Exam 2 value (growth)
7. Difference between Average 1 and Average 2

The the breeder, this report provides single growth and average growth information between two dates and comparisons between an animal's current state and the breed average.

d. Averages Report

The Averages Report is a statistical synopsis of all the conformation measurements for animals of the same breed, sex and age. It contains 6 columns of data for each of the 28 conformation entities. (See Figure 2 for a sample Averages Report).

The six columns for each conformational entity are:

1. Conformation entity name
2. Sample size
3. Average value
4. Standard Deviation
5. 95% Confidence Interval lower bound
6. 95% Confidence Interval upper bound

The Average Report allows a producer to evaluate a herd against the breed average, monitor trends within a breed and create quick comparisons between different breeds.

It should be noted that the value of the Averages Report will depend on the number of records in the database for the selected breed, sex and age (sample size). The averages contained in the report do not represent an ideal, but only a summary of the actual measurements encountered.

2. **Flexibility**

a. Modularity

The digitizer software has been rewritten in a modular fashion that will permit easy addition or modification of many potential capabilities. there are 10 different data windows available, of which only six are presently being used. Because each of these window/modules is independent to a large degree from the others, each can be modified without affecting the others. Producers or breeders who would like to see CDS expanded to include other measurements will be able to have their ideas added to the system with a minimum of time and effort.

b. Graphics Pad

The graphics pad is the key element of the data entry module. It transforms images on transparencies into numerical data that can be used by CDS to generate conformation measurements. The CDS prototype used only the Kurta Corporation Series II graphics pad. Many other manufacturers produce equally capable graphics pads, performing the same basic functions but using different interfaces. CDS has been adapted so that various popular graphics pads can be selected by the operator.

c. Video Hardware

Video hardware is constantly changing in today's microcomputer market and because of this, there are many popular graphics card/monitor combinations. The prototype worked with only the Colour Graphics Adapter (CGA) and was incompatible with the others. The software has now been modified so that CDS can automatically sense which card/monitor is being used on the computer system, and can adapt itself accordingly. CDS will now work correctly on the CGA standard, the Hercules standard, the popular EGA adapter and the new VGA adapter which is just breaking into the market at this time.

3. **Ease of Use**

a. Database manager

A database manager (DBM) has been created to organize and permanently store the animal data records and averages. The DBM can search for specific data and creates an environment where modification, addition or deletion of records is possible.

b. Menu Driven Interface

Because CDS will be used by operators who are not necessarily trained in the use of computers, it has been designed around a menu system. The novice user sees all the choices available from the current context, while the experienced user can skip the rigor of the menus by simply pressing the first letter of the menu keywords. This greatly shortens the learning curve and allows for quicker, more efficient operation as experience grows.

c. Help Screens throughout entire System

CDS now has an extensive set of on-screen help windows to provide a novice operator with quick reminders of the program's function and use. The help windows are context sensitive, meaning that only information relevant to the current operation will be displayed. This permits learning in small packets and a quick reference for more experienced users.

d. Operator's Manual started

A rough draft of the CDS Operator's Manual has been created. The manual contains all the information necessary to use CDS effectively and includes a set of technical appendices describing CDS's inner workings.

B. System Testing

There are two distinct phases of testing: lab testing and field testing. At the present time, lab testing is essentially complete and field testing is in the data collection phase.

1. Lab Testing (complete)

CDS has been rigorously tested in the lab using models. For the body measurements, the model chosen was a skeleton which has the same conformation as live animals but can be accurately measured by conventional methods. The hoof conformation was tested using real hooves collected from a slaughterhouse. A cardboard model of known area was used to test the Surface Area module.

Six tests have been performed. A brief description of each test and the results obtained follows.

Model Body Measurement

The model (skeleton) was prepared by sticking small dots at the location of each anatomical landmark. The value of each conformational entity was then carefully measured and recorded. The marked model was photographed using a 35 mm camera and 3 standard lenses (28 mm, 35 mm, and 55 mm). Each of the 3 resulting images was processed by CDS and the percent differences between the computer values and the hand measured values calculated. The results are shown in Table I.

Conformation Entity	28 mm Lens	35 mm Lens	55 mm Lens	Average (3 lenses)
Loin Height	1.84	1.41	1.07	1.44
Withers Height	2.09	1.75	1.84	1.89
Body Length	0.89	0.70	0.06	0.55
Chest Depth	1.14	0.88	1.07	1.03
Int Pelvic Angle	1.85	1.80	2.04	2.23
Fem Pelvic Angle	0.04	1.88	1.80	1.24
Hor Pelvic Angle	1.50	3.33	3.67	2.83
Hock Angle	0.19	2.75	1.69	1.54
Pelvic Length	0.99	0.85	2.90	1.58
Wing Length	1.89	1.00	0.89	1.26
Femur Length	3.69	1.28	1.77	2.25
Tibia Length	0.85	1.78	0.76	1.13
Hock Length	0.32	0.38	0.77	0.49
Humerus Length	1.25	1.16	0.45	0.95
Mean (all)	1.32	1.57	1.48	1.46
Mean (lengths)	1.50	1.12	1.16	1.26
Mean (angles)	0.90	2.69	2.30	1.96

Model Hoof Measurements

Three hoof models were selected, one representing 'normality', and the other two representing more extreme shapes and sizes. The three models were marked with small dots in a similar manner to the Body Model and the conformation values measured and recorded. Photographs were made using the 200 mm lens and the resulting images were processed by CDS. The percent differences between the computer values and the hand measureed values are tabulated in Table II.

Conformation Entity	Model 1 % Difference	Model 2 % Difference	Model 3 % Difference	Average % Difference
Heel Height	5.44	7.69	6.06	6.40
Claw Length	6.94	4.47	4.17	5.19
Toe Height	1.36	6.25	8.89	5.50
Toe Length	8.33	3.23	3.92	5.13
Toe Angle	1.33	7.85	3.58	4.25
Lateral Width	6.84	4.30	3.94	5.03
Medial Width	0.98	3.60	3.61	2.73
Mean Value	4.46	5.34	4.88	4.89

Table II - Hoof Model Results

The accuracy appears to be lower for the hoof measurements than it is for the body measurements. This may be because of the size of the conformational entities being evaluated. Most hoof measurements are about 5-10 cm in size and therefore, a 5% percent difference represents an absolute error in the range of 2-5 mm, which is approaching the accuracy of the equipment used. Attempts will be made to fine tune the hoof conformation calculations and make the accuracy more in line with the body conformation accuracy.

Model Area Measurements

The Surface Area Module was tested by creating a cardboard model of a closed convex region. The exact area was calculated by precisely weighing the cardboard pieces and calculating the ratio of the two parts. The region was then processed by the CDS area module and the percent difference between the computer value and the measured value determined. The resulting percent difference between the measured area and the CDS generated value was 1.36%.

Model Body Measurements with Lateral Camera Shift

The effect on the body conformation measurements was checked when the camera position was varied laterally. The film plane was kept perpendicular to the sagittal plane of the model while the camera position was varied from 1 meter to the left and right of center in 0.20 meter increments. Each of the eleven resulting images was processed by CDS and the difference between each conformational field and the center position value was determined. The mean percent difference over all fields was generated and plotted against the camera position.

The graphs in Figures 3,4 and 5 show that the accuracy appears to degenerate as the camera is moved away from center. However, the error margin never surpasses about 2 percent which can be entirely accounted for by statistical fluctuations due to the inherent machine error. Thus, the test shows that as long as the film plane remains parallel with the sagittal plane of the animal, accuracy is not affected.

Model Body Measurements with Camera Proximity Shift

The camera to model distance was varied to determine if there was an optimal camera distance or if the standard lenses were accurate throughout their focal range. Several images were made at various distances from the model. These images were processed by CDS and the generated results for each field compared with the actual measured values. The mean percent difference over all fields was plotted against the camera distance.

The graphs in Figures 6, 7 and 8 show that for each of the three lenses tested, there is no optimal camera distance. The percent difference never increases above the level of statistical noise caused by machine error. Thus, it can be argued that the lenses tested will give good results throughout their normal operating range.

2. Field Testing

a. ROP bulls were photographed in 1988. Once the CDS program has been finally refined the information was digitized. The resulting information was collated in the tables 1 - 11. These tables illustrate the value of CDS generated data.

b. We wished to acertain if repeatability varied between operators and differed between sites measured. This is illustrated in tables 12-26 and indicates that some workers are more adapt than others and that some locations are easier to measure than others. Ten students were used to conduct this trial. Each measured the same cow on ten different occasions. It should however, be noted that this trial was conducted with individuals who had no experience. This led us to conclude that taking several photographs of the same animal would increase accuracy and that limiting the persons using the technique would improve the consistency of results.

Conclusions and Impact

Involvement with this project has stimulated the project supervisor (Greenough) to become more involved in the implications of conformation evaluation especially as it related to the beef industry. It is apparent that breed societies are locked in to the show circuit and the judging standards, many of which are dictated by agencies in the U.S. In strict contract the commercial beef breeders is greatly concerned about the functional efficiency of their animals and their concern about feet and legs has prompted the current study. The commercial industry wants and needs guidance and information such as can be provided by CDS. There is no doubt that longevity, calvability and market satisfaction would benefit from objective evaluation of conformation as is possible through a system such as CDS.

CDS is capable of further modification to be customed even more to the needs of the industry. The accuracy of the system is likely to be adequate to meet practical needs. However, the system as it stands could be made more flexible and therefore more appealing to the producer if it were adapted to be used through a television system.

Marking animals must be undertaken by a person who has had some training although the individual so trained need have no special academic background. Therefore, it is quite possible that a service could be provided to commercial producers but it may not be possible to provide that service through breed societies. Progress in adopting CDS is therefore probably limited by logistics rather than lack of interest.

A large body of animal scientists are interested in research that relate production to characteristics of conformation. The literature on the topic is prolific. The reports suffer from a common weakness, most are based on descriptive traits rather than objective measurements. CDS provides a solution to the dilemma and this accounts for the enthusiasm observed by the research workers who have been exposed to the system. Again progress will be slow until the system is accepted.

There is no doubt that CDS could have an enormous impact on the industry and on related research. Genetic selection for conformation traits could be based on scientifically produced principles rather than opinion and bias. Unfortunately, technology transfer in this case presents many problems which are beyond the scope of the present project.

c. Papers and Talks:

Papers

Greenough PR, Berg PA, Vermunt JJ, Koehler JA. 1990 The conformation determination system (CDS) - A computerized Photogrammetric Technique for Measuring and Recording Bovine Skeletal Size and Angularity. Abstracted in Proceedings of the International Symposium of Breeding Disease Resistance in Farm Animals. Bangor UK. Submitted for publication in Veterinary Record.

Greenough PR and Vermunt JJ 1990. A Rationale for Selecting Variables for Body Measurements of Cattle and the Precise Location of Anatomical Landmarks. Abstracted in Proceedings of the International Symposium of Breeding Disease Resistance in Farm Animals. Bangor UK. Submitted for publication Veterinary Record.

Greenough PR (1988) Objective Studies in Bovine Conformation. Proceedings XVth World Buiatrics Congress, Mallorca, Spain.

Greenough PR (1987) A Method for Measuring Conformation of Cattle from a 35 mm Transparency with Digitizing Pad and Computer, Proceedings of the World Veterinary Congress Montreal.

Greenough PR. 1987 What's wrong with the feet and legs of bulls. The Cattleman September 1986. Reprinted in Australian Beef Cattle review. 1987.

Te Plate HAM (1990) Description and Evaluation of Measuring Rear Legs, Side and Rear View using a Photogrammetric Technique in Holstein Heifers. Report for Dept. of Animal Science, N. Carolina State University.

Talks

Bovine Feet and Leg Problems, SVMA Mid Winter Convention, Saskatoon. 1989.

Evaluation of Bulls, Pasture Managers Conference, Saskatoon.

Effect of Rations on Feet and Legs and Identification of Feet and Leg Problems. National Bull Test Seminar, Regina.

A New Computer System for Assigning a Measured, Objective Value to Cow Conformation. Alberta Dairy Seminar, Banff, Alberta.

Bovine Conformation. Faculty/Student Seminar, Royal Danish Agriculture and Veterinary Institute, Copenhagen.

Genetic Improvement of Livestock Conformation. Royal Netherlands Herdbook Society, Arnhem, Holland.

Conformation Evaluation in Cattle, Association for Livestock Breeding and Production, Eskilstuna, Sweden.

Conformation Determination System. British Holstein Society/Milk Marketing Board, Thames Ditton, UK.

Conformation Determination System. Canadian Holstein Association, Brantford, Ontario.

Posters/Demonstrations

Beef in the 80's. Saskatoon. 1990

International Symposium on Disease Resistance in Farm Animals, Bangor, Wales UK. 1990

Agribition 1989 and 1988

G.A.T.E. Saskatoon 1989

Canadian Veterinary Medical Association Conference 1988

d. Statement of Expenditures:

To be supplied by the University of Saskatchewan.

e. Personnel:

Paul Greenough	Project Supervisor	10%
Philip Berg	Computer Programmer	100% (Until Jan. 1, 1990)
Jos Vermunt	Research Associate	10%
Michael Ogunyele	Technical Assistant	10%

f. Equipment: (Over $500)

a. Datatron 80296 Computer. Total cost of this unit was $4,380, however, only $2,624 was allocated from the project budget, the balance was accumulated from other sources.

b. Display panels were produced for the GATE demonstration at the request of the ADF. The full cost of the displays was $901.94 but only $500 was charged to the project budget.

c. Used photographic equipment was acquired for a total cost of $554 cost of but no single item exceeded $325 (used camera).

TABLE 3. AVERAGE BODY MEASUREMENTS OF ABERDEEN ANGUS BULL CALVES AT DIFFERENT AGES (SASKATOON R.O.P. STATION, 1988).

Description of measurements	8 mo	9 mo	10 mo	11 mo	12 mo
Weight (kg)	299.7	322.4	413.7	471.8	525.1
Height at loin (cm)	115.2	117.0	117.2	125.1	126.7
Height at withers (cm)	107.0	111.8	113.2	116.1	119.6
Height at shoulder (cm)	68.7	73.9	78.3	76.5	79.8
Body length (cm)	117.3	122.4	124.4	128.4	133.2
Chest depth (cm)	62.6	65.1	67.0	70.3	72.5
Sample Size	29	18	3	12	35

Description of body angles	8 mo	9 mo	10 mo	11 mo	12 mo
Internal pelvic angle	135.7	138.0	137.2	134.9	136.2
Femur/pelvis angle	82.3	83.2	86.8	89.4	88.2
Slope of pelvis	14.4	14.5	14.5	15.3	15.2
Angle of hock	160.8	169.7	157.3	162.8	162.9
Sample Size	29	18	3	12	35

Description of bone lengths	8 mo	9 mo	10 mo	11 mo	12 mo
Pin to hook length	39.2	39.5	38.9	39.6	41.3
Thurl to hook length	25.1	24.7	23.8	25.0	26.4
Length of femur	34.1	34.5	38.5	40.6	41.6
Length of tibia	31.6	31.5	28.2	27.6	28.4
Point of hock to tip of claw	49.5	50.0	50.2	52.2	52.3
Length of humerus	23.5	27.7	27.3	27.2	28.0
Sample Size	29	18	3	12	35

TABLE 4. AVERAGE BODY MEASUREMENTS OF HEREFORD BULL CALVES AT DIFFERENT AGES (SASKATOON R.O.P. STATION, 1988).

Description of measurements	8 mo	9 mo	10 mo	11 mo	12 mo
Weight (kg)	289.9	292.6	360.7	471.6	503.3
Height at loin (cm)	116.6	116.5	118.7	127.2	126.5
Height at withers (cm)	108.5	108.0	109.0	117.6	118.8
Height at shoulder (cm)	72.7	70.2	70.0	76.7	77.2
Body length (cm)	116.5	117.2	119.0	128.5	131.0
Chest depth (cm)	62.4	62.1	63.3	70.0	73.0
Sample Size	22	16	3	21	21

Description of body angles	8 mo	9 mo	10 mo	11 mo	12 mo
Internal pelvic angle	132.8	132.7	135.2	136.1	137.9
Femur/pelvis angle	82.5	83.4	85.9	90.2	90.4
Slope of pelvis	16.1	15.1	14.2	16.3	14.7
Angle of hock	161.2	160.7	165.1	161.8	162.5
Sample Size	22	16	3	21	21

Description of bone lengths	8 mo	9 mo	10 mo	11 mo	12 mo
Pin to hook length	38.4	38.8	39.9	41.2	42.5
Thurl to hook length	25.4	24.9	25.6	25.7	26.6
Length of femur	35.1	34.3	36.9	39.9	41.8
Length of tibia	30.2	29.5	28.4	29.6	28.7
Point of hock to tip of claw	50.2	49.8	50.3	52.6	52.3
Length of humerus	25.5	24.7	25.2	25.8	27.3
Sample Size	22	16	3	21	21

TABLE 5. AVERAGE BODY MEASUREMENTS OF CHAROLAIS BULL CALVES AT DIFFERENT AGES (SASKATOON R.O.P. STATION, 1988).

Description of measurements	8 mo	9 mo	10 mo	11 mo	12 mo
Weight (kg)	313.3	351.9	383.9	522.1	567.7
Height at loin (cm)	121.5	123.2	125.5	131.5	134.3
Height at withers (cm)	111.0	114.4	116.8	120.5	123.0
Height at shoulder (cm)	75.7	78.0	80.7	80.8	81.8
Body length (cm)	119.8	123.4	127.8	133.4	138.8
Chest depth (cm)	61.5	63.4	64.6	68.4	70.7
Sample Size	41	27	10	32	35

Description of body angles	8 mo	9 mo	10 mo	11 mo	12 mo
Internal pelvic angle	135.6	136.5	139.7	137.9	138.4
Femur/pelvis angle	83.4	81.8	81.7	91.9	90.4
Slope of pelvis	16.0	15.4	14.5	14.6	14.5
Angle of hock	158.1	160.1	157.8	161.8	163.0
Sample Size	41	27	10	32	35

Description of bone lengths	8 mo	9 mo	10 mo	11 mo	12 mo
Pin to hook length	38.6	40.2	41.5	41.9	43.3
Thurl to hook length	25.1	26.5	27.0	26.3	27.8
Length of femur	34.7	35.7	37.5	43.0	44.6
Length of tibia	35.0	34.6	35.0	29.2	28.5
Point of hock to tip of claw	53.0	53.2	54.3	56.2	57.1
Length of humerus	25.8	27.4	28.5	29.0	29.7
Sample Size	41	27	10	32	35

TABLE 6. AVERAGE BODY MEASUREMENTS OF SIMMENTAL CALVES AT DIFFERENT AGES (SASKATOON R.O.P. STATION, 1988).

Description of measurements	8 mo	9 mo	10 mo	11 mo	12 mo
Weight (kg)	336.0	356.1	458.8	513.8	573.8
Height at loin (cm)	121.7	125.3	131.0	135.0	135.1
Height at withers (cm)	112.7	115.5	124.1	125.3	126.9
Height at shoulder (cm)	76.6	77.9	84.9	84.5	83.9
Body length (cm)	120.6	124.0	135.2	138.3	140.4
Chest depth (cm)	61.6	62.2	69.3	70.5	71.0
Sample Size	22	17	4	15	25

Description of body angles	8 mo	9 mo	10 mo	11 mo	12 mo
Internal pelvic angle	132.3	134.4	136.3	137.3	138.0
Femur/pelvis angle	80.9	78.9	82.3	87.8	87.3
Slope of pelvis	15.8	14.5	15.6	14.1	13.6
Angle of hock	163.1	160.9	165.2	165.3	166.0
Sample Size	22	17	4	15	25

Description of bone lengths	8 mo	9 mo	10 mo	11 mo	12 mo
Pin to hook length	38.6	40.3	41.5	41.8	43.1
Thurl to hook length	25.9	27.0	28.4	26.5	27.7
Length of femur	35.1	38.3	41.4	44.5	45.4
Length of tibia	32.8	32.7	31.8	28.2	28.9
Point of hock to tip of claw	52.2	53.3	54.3	56.9	56.8
Length of humerus	26.8	27.5	29.3	29.0	30.6
Sample Size	22	17	4	15	25

TABLE 7. AVERAGE BODY MEASUREMENTS OF FOUR BREEDS OF CALVES AT 8 MONTHS OLD (SASKATOON R.O.P. STATION, 1988).

Description of measurements	Ang	Char	Her	Sim
Weight (Kg)	299.7	313.3	289.9	336.0
Height at loin (cm)	115.2	121.5	116.6	121.7
Height at withers (cm)	107.0	111.0	108.5	112.7
Height at shoulder (cm)	68.7	75.7	72.7	76.6
Body length (cm)	117.3	119.8	116.5	120.6
Chest depth (cm)	62.6	61.5	62.4	61.6
Sample Size	29	41	22	22

Description of body angles	Ang	Char	Her	Sim
Internal pelvic angle	135.7	135.6	132.8	132.3
Femur/pelvis angle	82.3	83.4	82.5	80.9
Slope of pelvis (rump)	14.4	16.0	16.1	15.8
Angle of hock	160.8	158.1	161.2	163.1
Sample Size	29	41	22	22

Description of bone lengths	Ang	Char	Her	Sim
Pin to hook length	39.2	38.6	38.4	38.6
Thurl to hook length	25.1	25.1	25.4	25.9
Length of femur	34.1	34.7	35.1	35.1
Length of tibia	31.6	35.0	30.2	32.8
Point of hock to tip of claw	49.5	53.0	50.2	52.2
Length of humerus	23.5	25.8	25.5	26.8
Sample Size	29	41	22	22

TABLE 8. AVERAGE BODY MEASUREMENTS OF FOUR BREEDS OF CALVES AT 9 MONTHS OLD (SASKATOON R.O.P. STATION, 1988).

Description of measurements	Ang	Char	Her	Sim
Weight (Kg)	322.4	351.9	292.6	356.1
Height at loin (cm)	117.0	123.2	116.5	125.3
Height at withers (cm)	111.8	114.4	108.0	115.5
Height at shoulder (cm)	73.9	78.0	70.2	77.9
Body length (cm)	122.4	123.4	117.2	124.0
Chest depth (cm)	65.1	63.4	62.1	62.2
Sample Size	18	27	16	17

Description of body angles	Ang	Char	Her	Sim
Internal pelvic angle	138.0	136.5	132.7	134.4
Femur/pelvis angle	83.2	81.8	83.4	78.9
Slope of pelvis (rump)	14.5	15.4	15.1	14.5
Angle of hock	169.7	160.1	160.7	160.9
Sample Size	18	27	16	17

Description of bone lenghts	Ang	Char	Her	Sim
Pin to hook length	39.5	40.2	38.8	40.3
Thurl to hook length	24.7	26.5	24.9	27.0
Length of femur	34.5	35.7	34.3	38.3
Length of tibia	31.5	34.6	29.5	32.7
Point of hock to tip of claw	50.0	53.2	49.8	53.3
Length of humerus	27.7	27.4	24.7	27.5
Sample Size	18	27	16	17

TABLE 9. AVERAGE BODY MEASUREMENTS OF FOUR BREEDS OF CALVES AT 10 MONTHS OLD (SASKATOON R.O.P. STATION, 1988).

Description of measurements	Ang	Char	Her	Sim
Weight (Kg)	413.7	383.9	360.7	458.8
Height at loin (cm)	117.2	125.6	118.7	131.0
Height at withers (cm)	113.2	116.8	109.0	124.1
Height at shoulder (cm)	78.3	80.7	70.0	84.9
Body length (cm)	124.4	127.8	119.0	135.2
Chest depth (cm)	67.0	64.6	63.3	69.3
Sample Size	3	10	3	4

Description of body angles	Ang	Char	Her	Sim
Internal pelvic angle	137.2	139.7	135.2	136.3
Femur/pelvis angle	86.8	81.7	85.9	82.3
Slope of pelvis (rump)	14.5	14.5	14.2	15.6
Angle of hock	157.3	157.8	165.1	165.2
Sample Size	3	10	3	4

Description of bone lengths	Ang	Char	Her	Sim
Pin to hook length	38.9	41.5	39.9	41.5
Thurl to hook length	23.8	27.0	25.6	28.4
Length of femur	38.5	37.5	36.9	41.4
Length of tibia	28.2	35.0	28.4	31.8
Point of hock to tip of claw	50.2	54.3	50.3	54.3
Length of humerus	27.3	28.5	25.2	29.3
Sample Size	3	10	3	4

TABLE 10. AVERAGE BODY MEASUREMENTS OF FOUR BREEDS OF CALVES AT 11 MONTHS OLD (SASKATOON R.O.P. STATION, 1988).

Description of measurements	Ang	Char	Her	Sim
Weight (Kg)	471.8	522.1	471.6	513.8
Height at loin (cm)	125.1	131.5	126.5	135.0
Height at withers (cm)	116.1	120.5	117.6	125.3
Height at shoulder (cm)	76.5	80.8	76.7	84.5
Body length (cm)	128.4	133.4	128.5	138.3
Chest depth (cm)	70.3	68.4	70.0	70.5
Sample Size	12	32	21	15

Description of body angles	Ang	Char	Her	Sim
Internal pelvic angle	134.9	137.9	136.1	137.3
Femur/pelvis angle	89.4	91.9	90.2	87.8
Slope of pelvis (rump)	15.3	14.6	16.3	14.1
Angle of hock	162.8	161.8	161.8	165.3
Sample Size	12	32	21	15

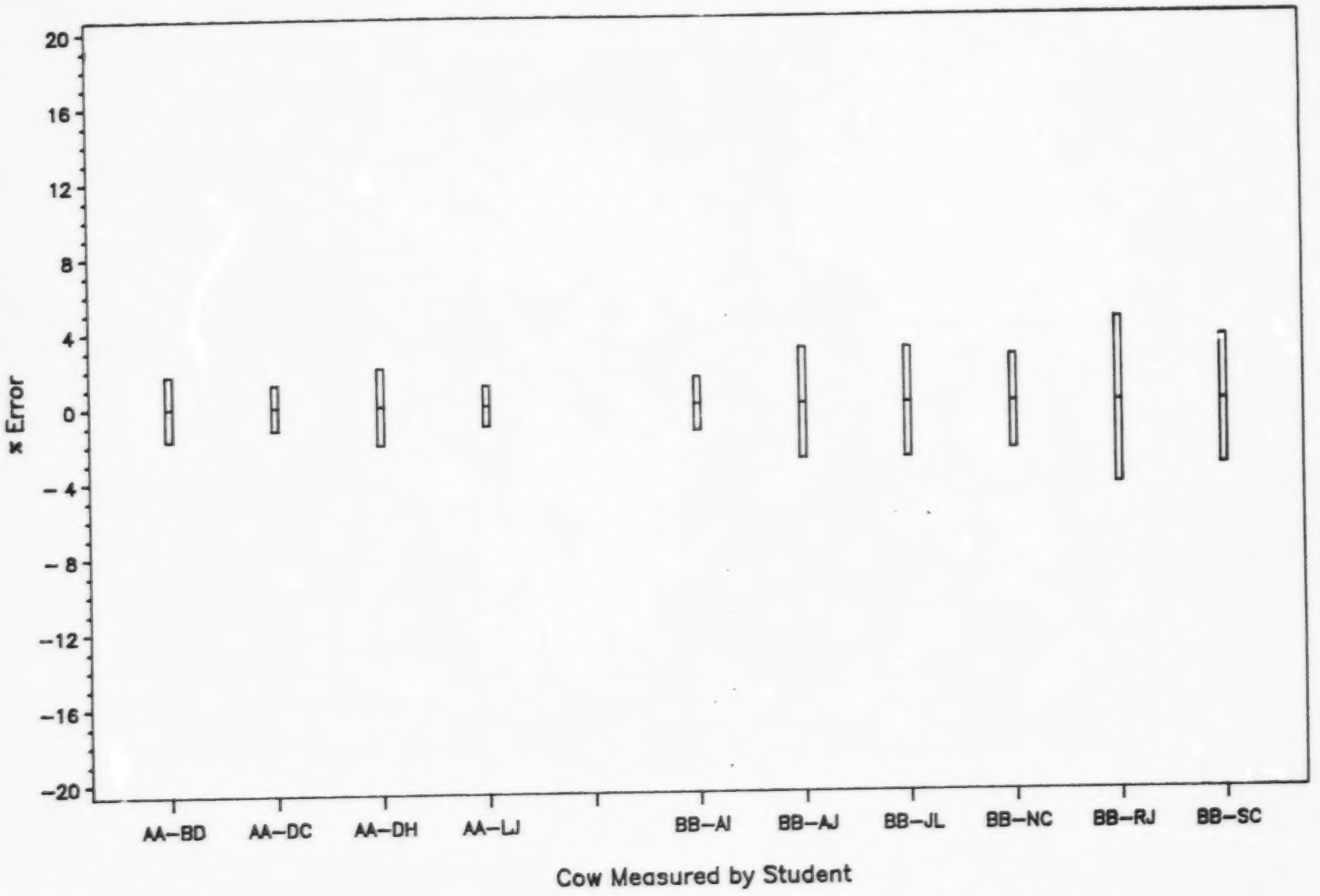
Description of bone lengths	Ang	Char	Her	Sim
Pin to hook length	39.6	41.9	41.2	41.8
Thurl to hook length	25.0	26.3	25.7	26.5
Length of femur	40.6	43.0	39.9	44.5
Length of tibia	27.6	29.2	29.6	28.2
Point of hock to tip of claw	52.2	56.2	52.6	56.9
Length of humerus	27.2	29.0	25.8	29.0
Sample Size	12	32	21	15

TABLE 11. AVERAGE BODY MEASUREMENTS OF FOUR BREEDS OF CALVES AT 12 MONTHS OLD (SASKATOON R.O.P. STATION, 1988).

Description of measurements	Ang	Char	Her	Sim
Weight (Kg)	525.1	567.7	503.3	573.8
Height at loin (cm)	126.7	134.3	127.2	135.1
Height at withers (cm)	119.6	123.0	118.8	126.9
Height at shoulder (cm)	79.8	81.8	77.2	83.9
Body length (cm)	133.2	138.8	131.0	140.4
Chest depth (cm)	72.5	70.7	73.0	71.0
Sample Size	35	35	21	25

Description of body angles	Ang	Char	Her	Sim
Internal pelvic angle	136.2	138.4	137.9	138.0
Femur/pelvis angle	88.2	90.5	90.4	87.3
Slope of pelvis (rump)	15.2	14.5	14.7	13.6
Angle of hock	162.9	163.0	162.5	166.0
Sample Size	35	35	21	25

Description of bone lengths	Ang	Char	Her	Sim
Pin to hook length	41.3	43.3	42.5	43.1
Thurl to hook length	26.4	27.8	26.6	27.7
Length of femur	41.6	44.6	41.8	45.4
Length of tibia	28.4	28.5	28.7	28.9
Point of hock to tip of claw	52.3	57.1	52.3	56.8
Length of humerus	28.0	29.7	27.3	30.6
Sample Size	35	35	21	25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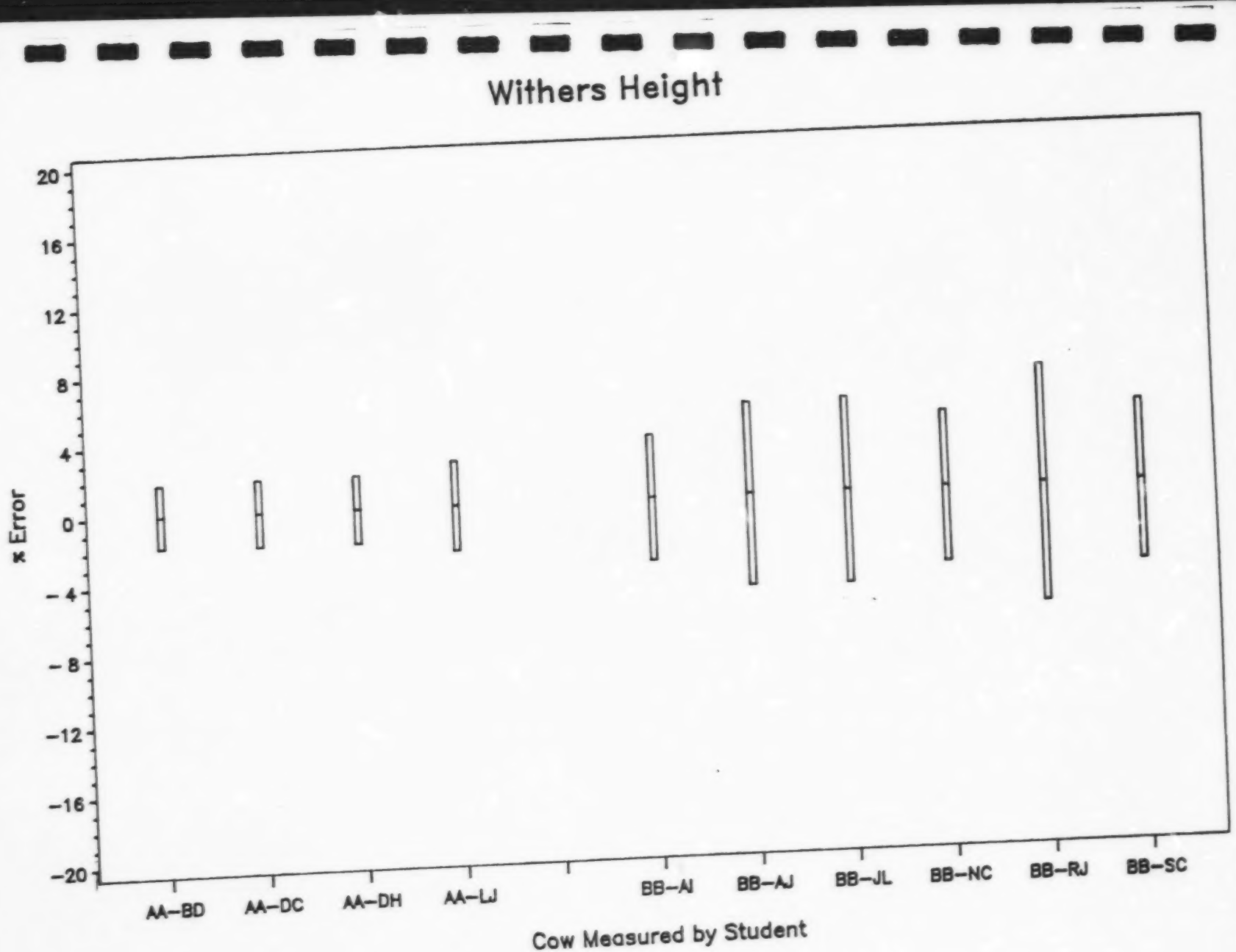
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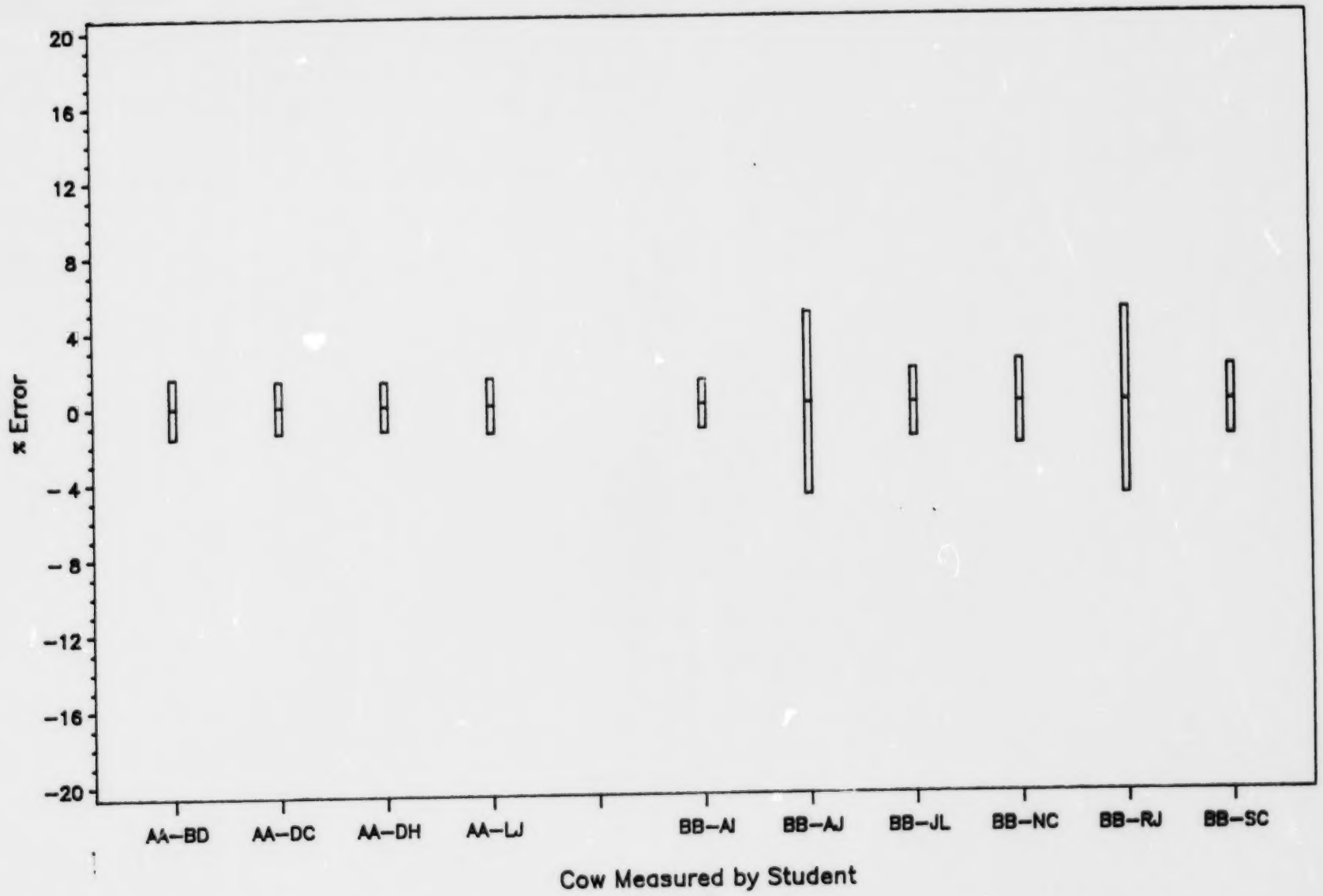
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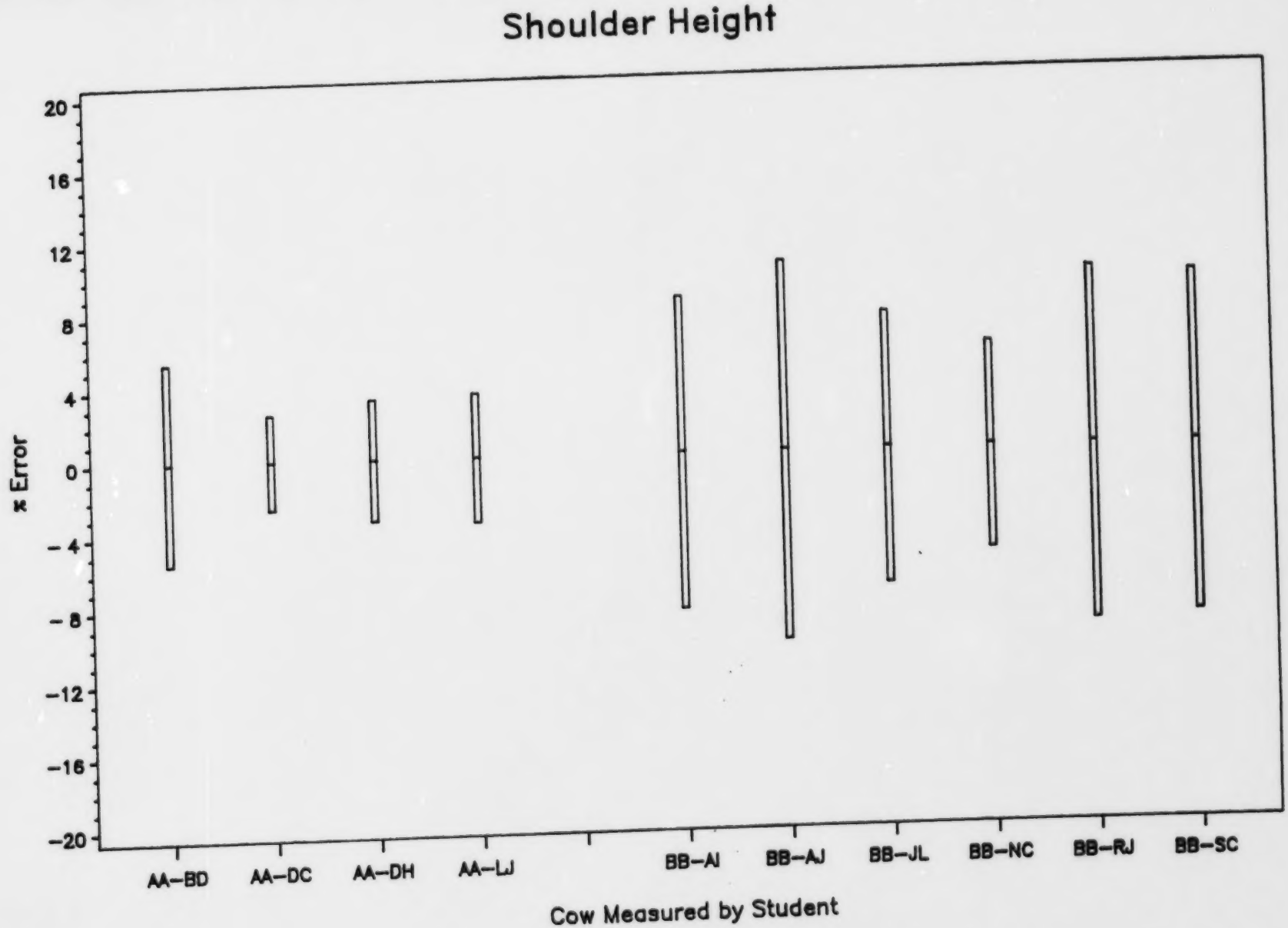
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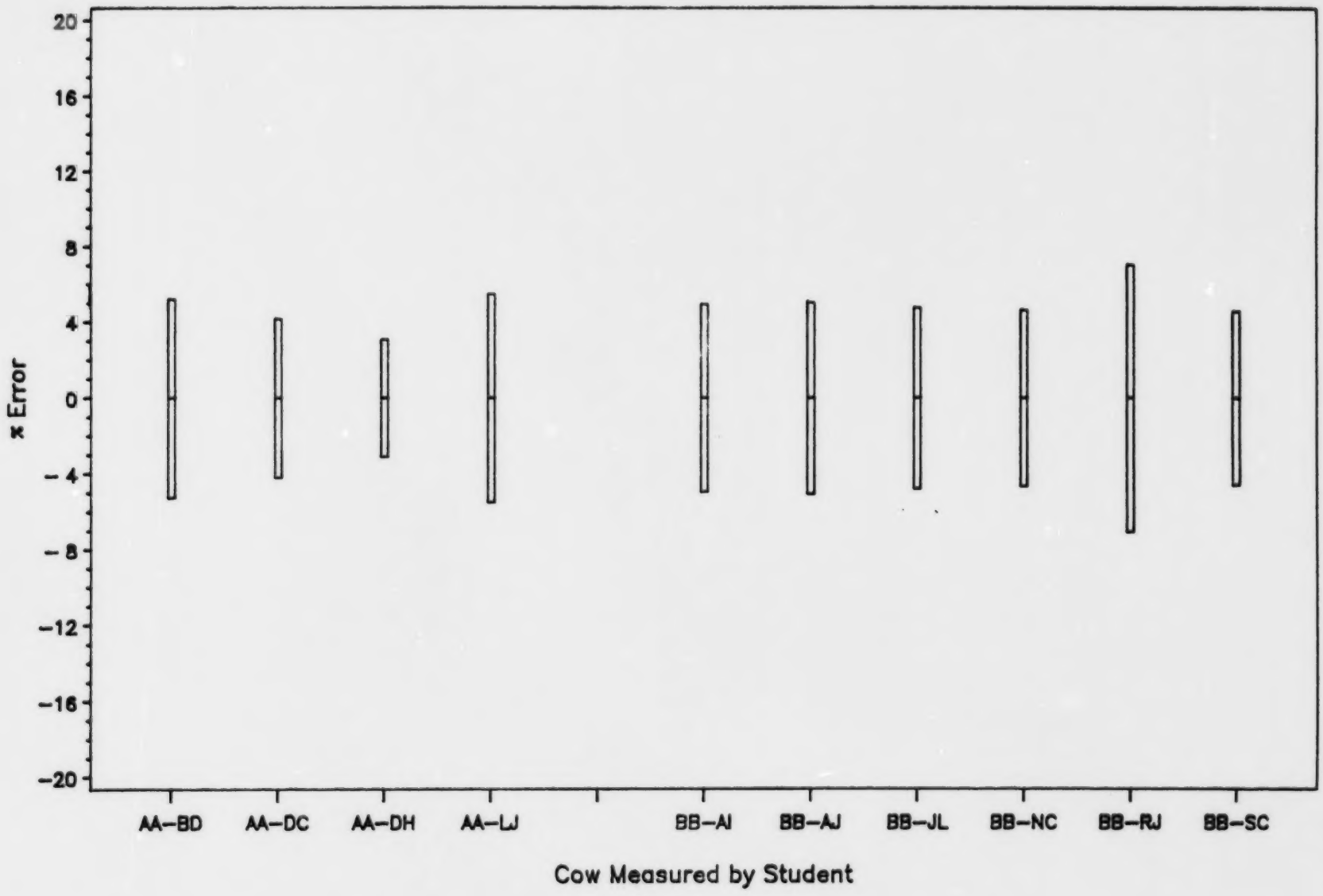
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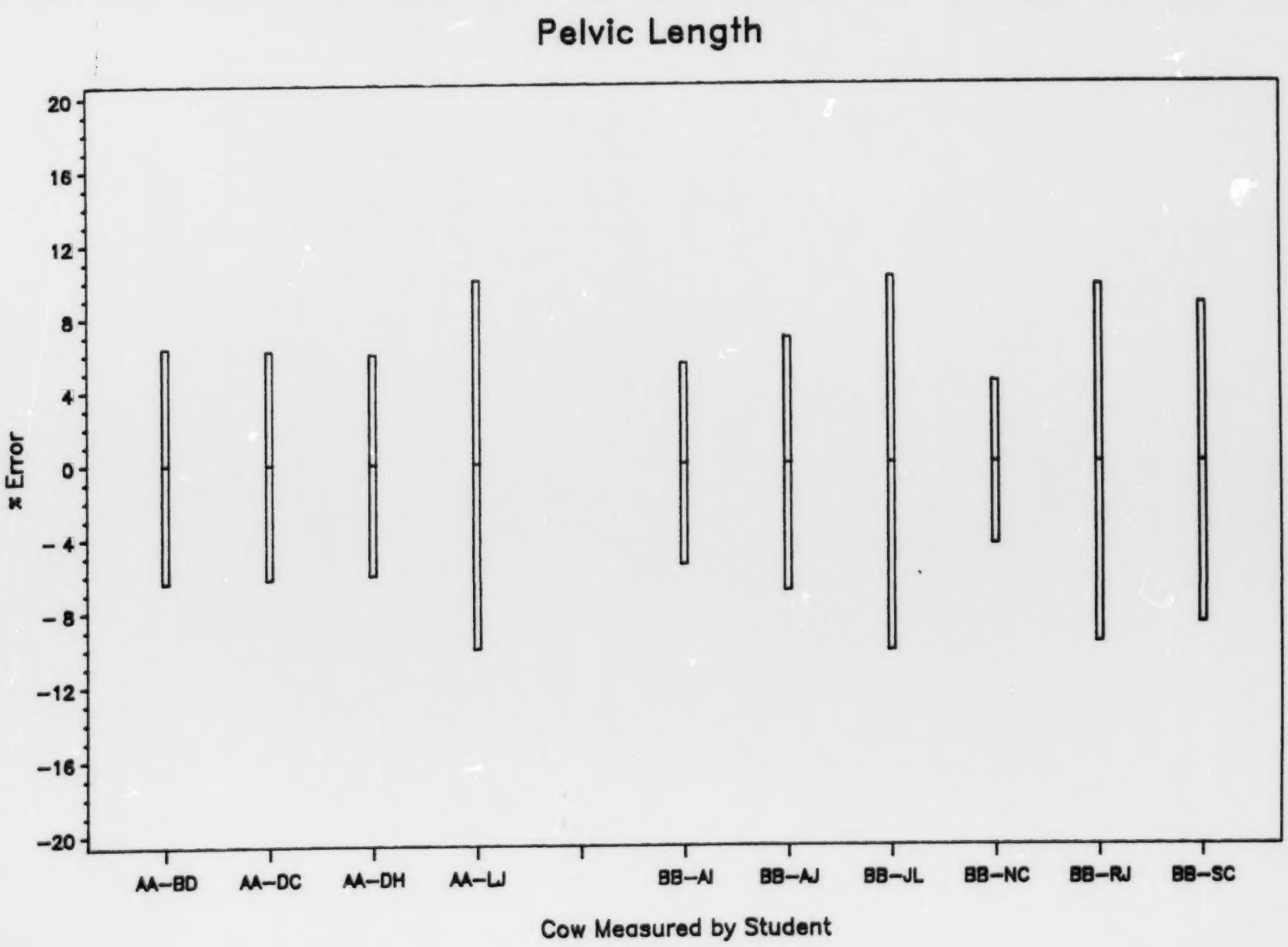
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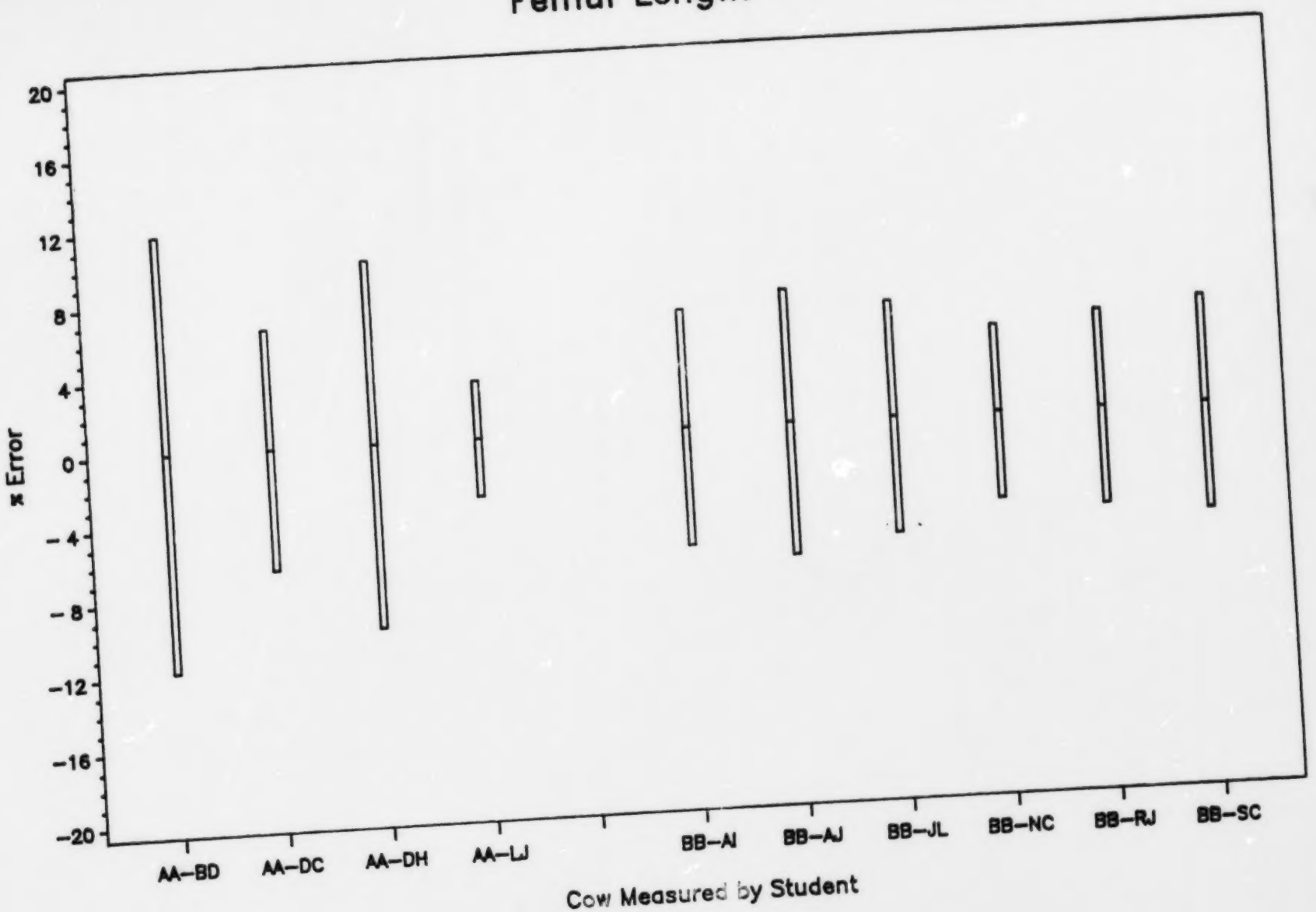
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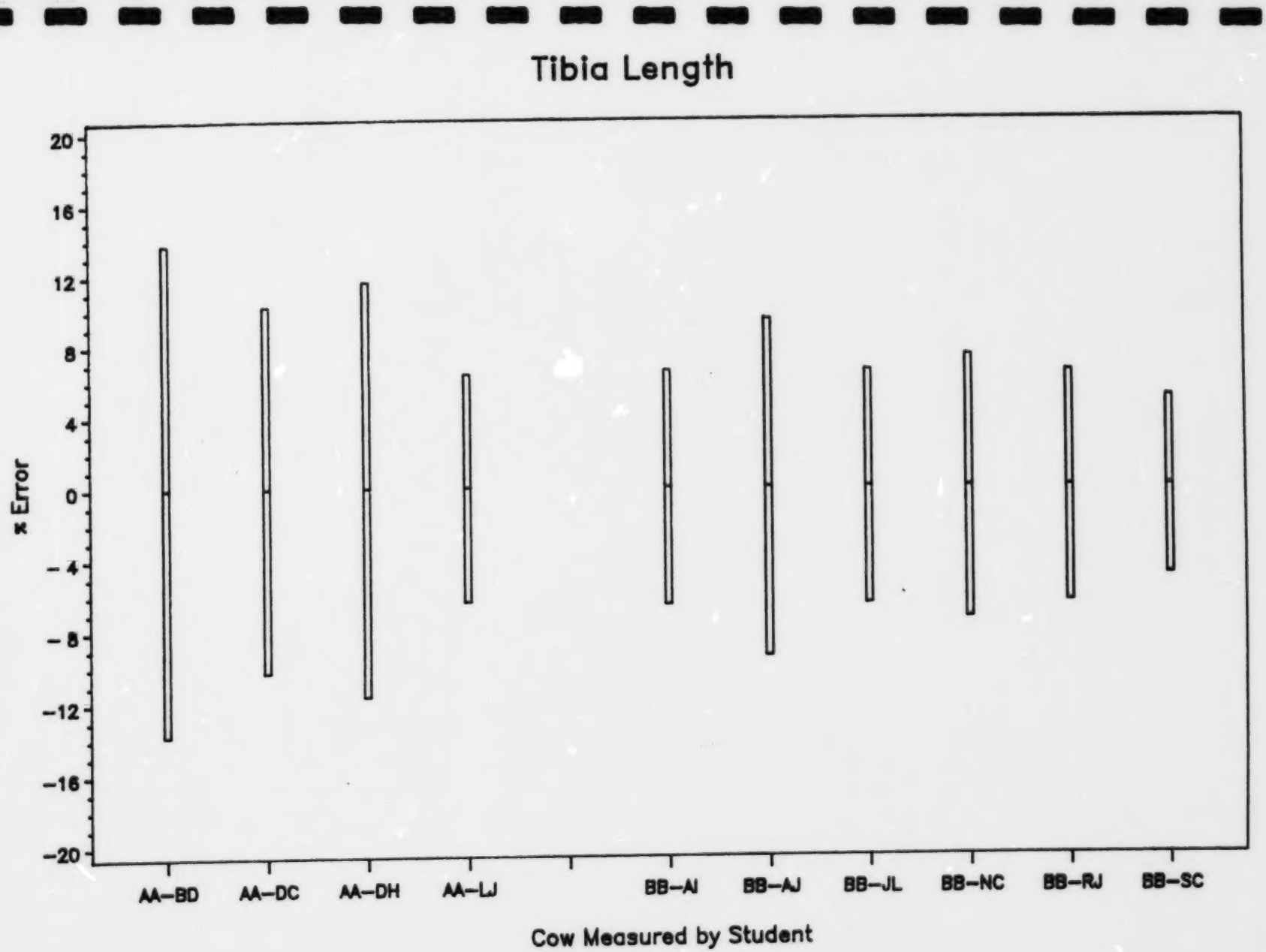
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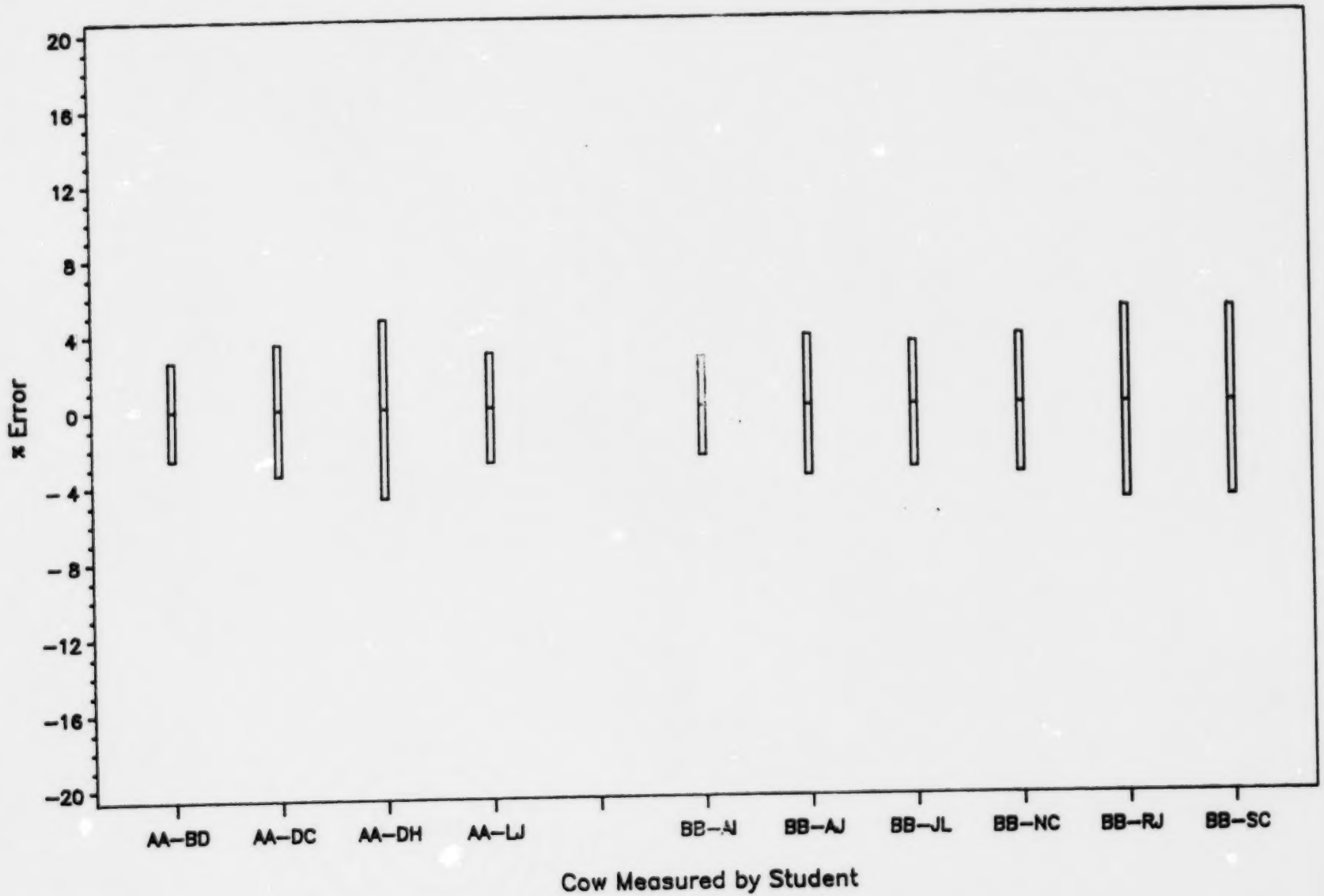
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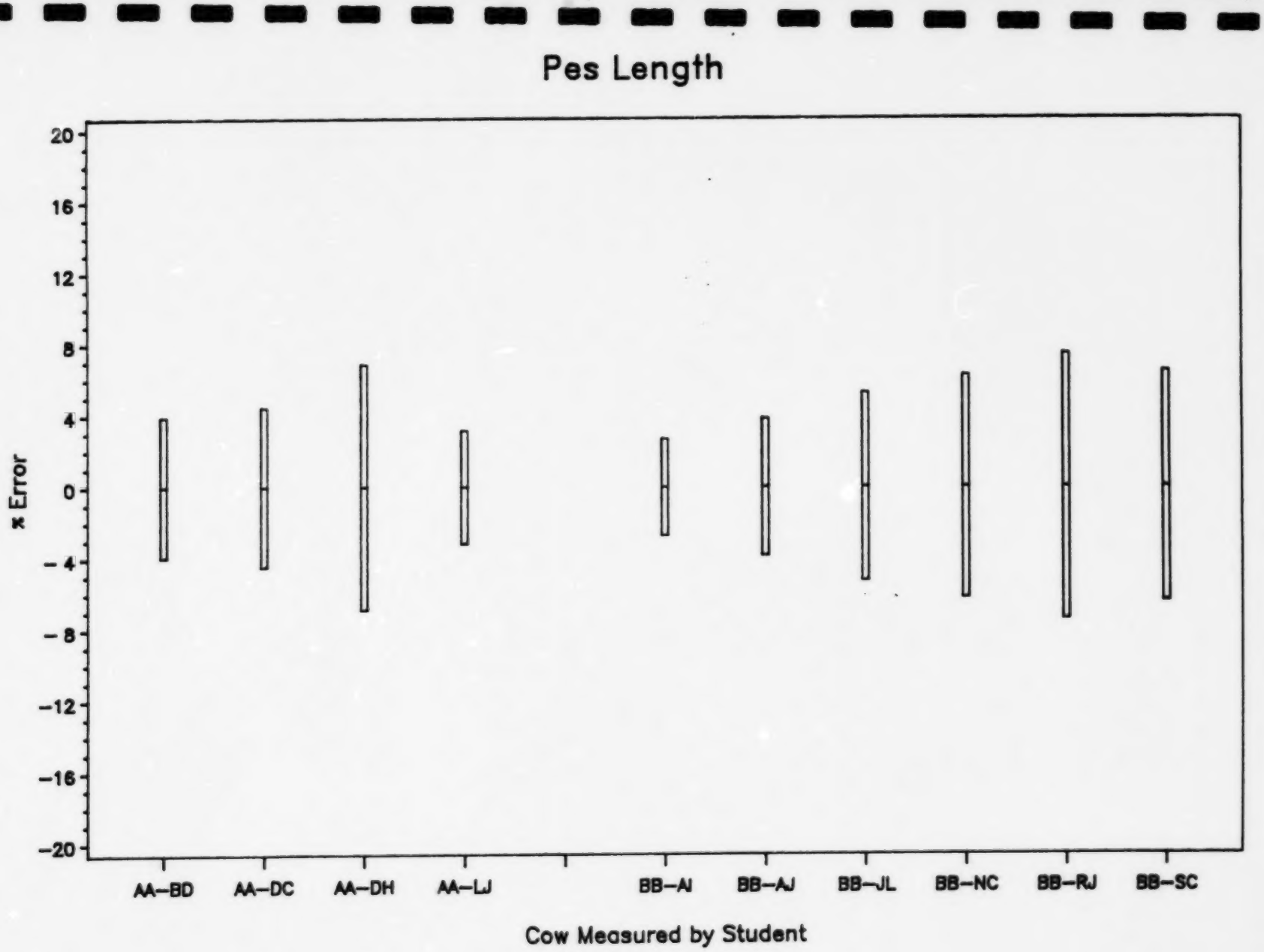
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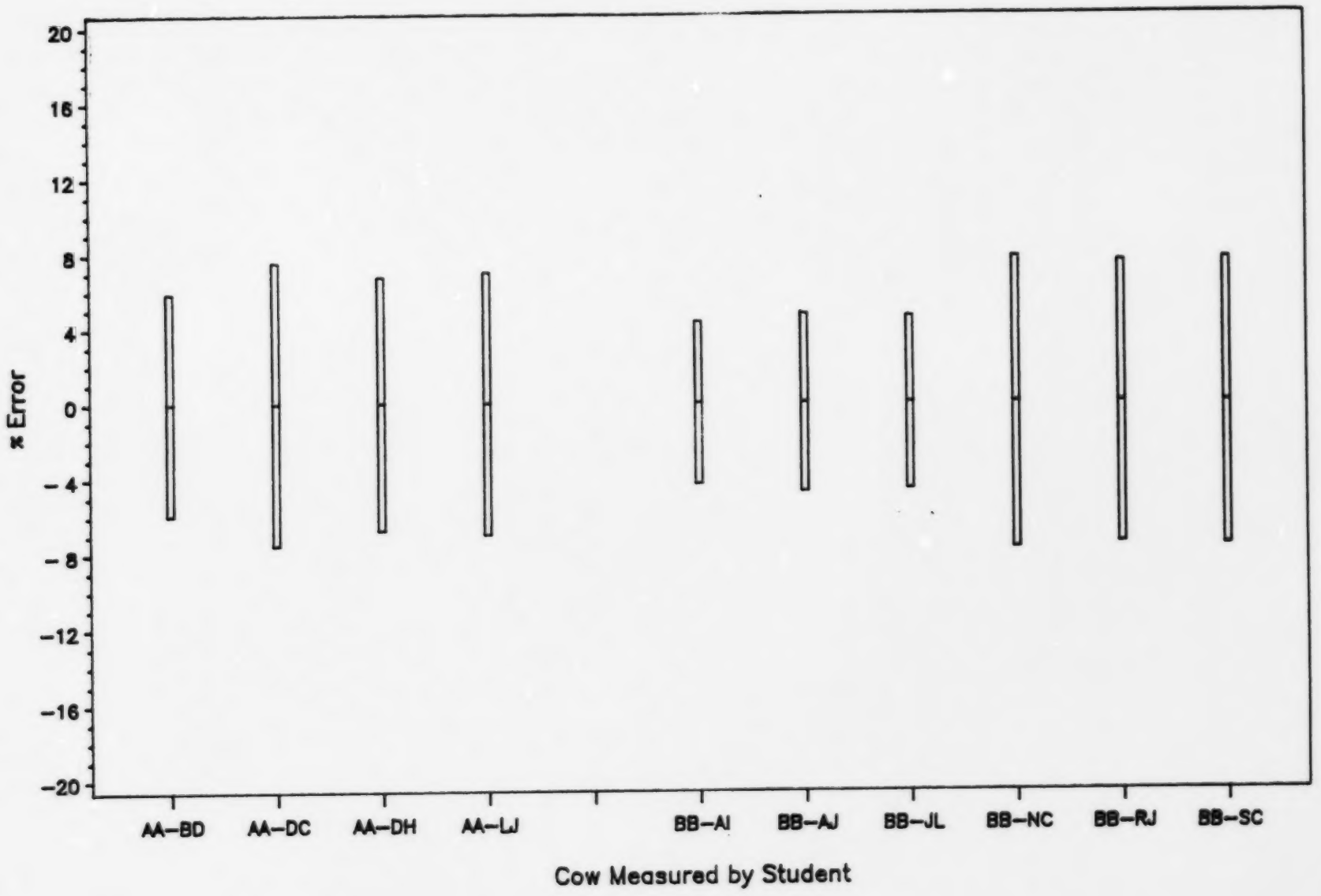

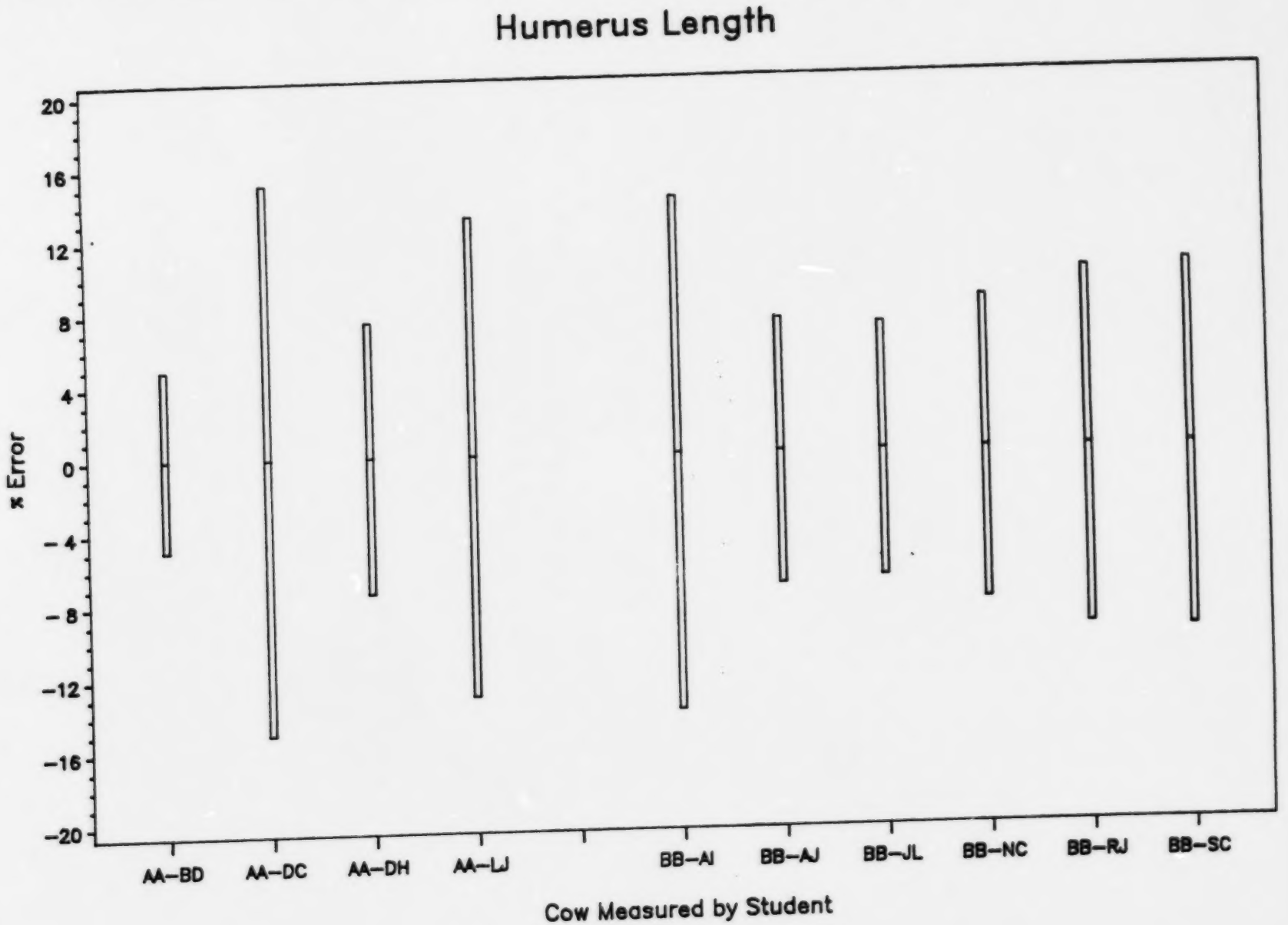
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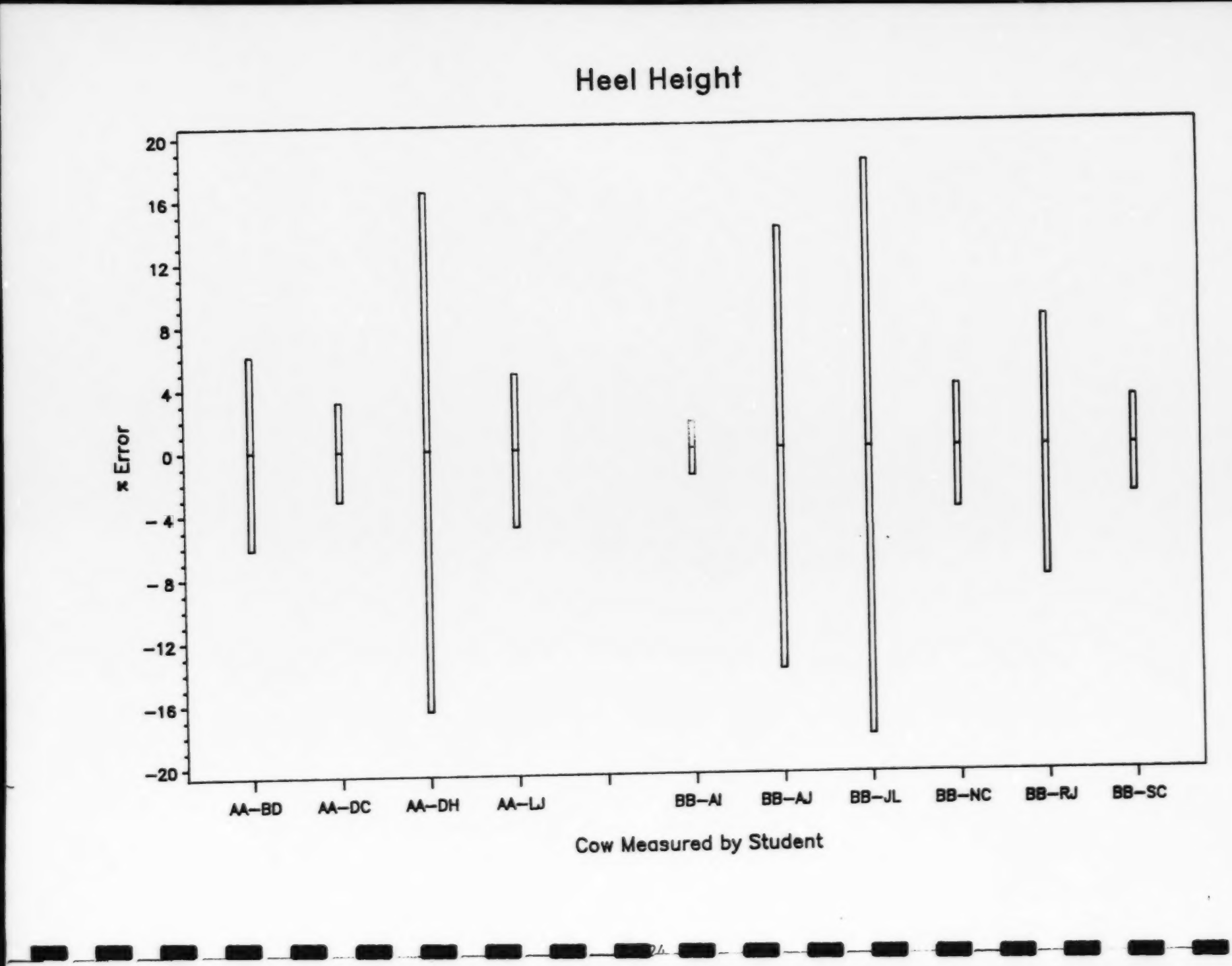
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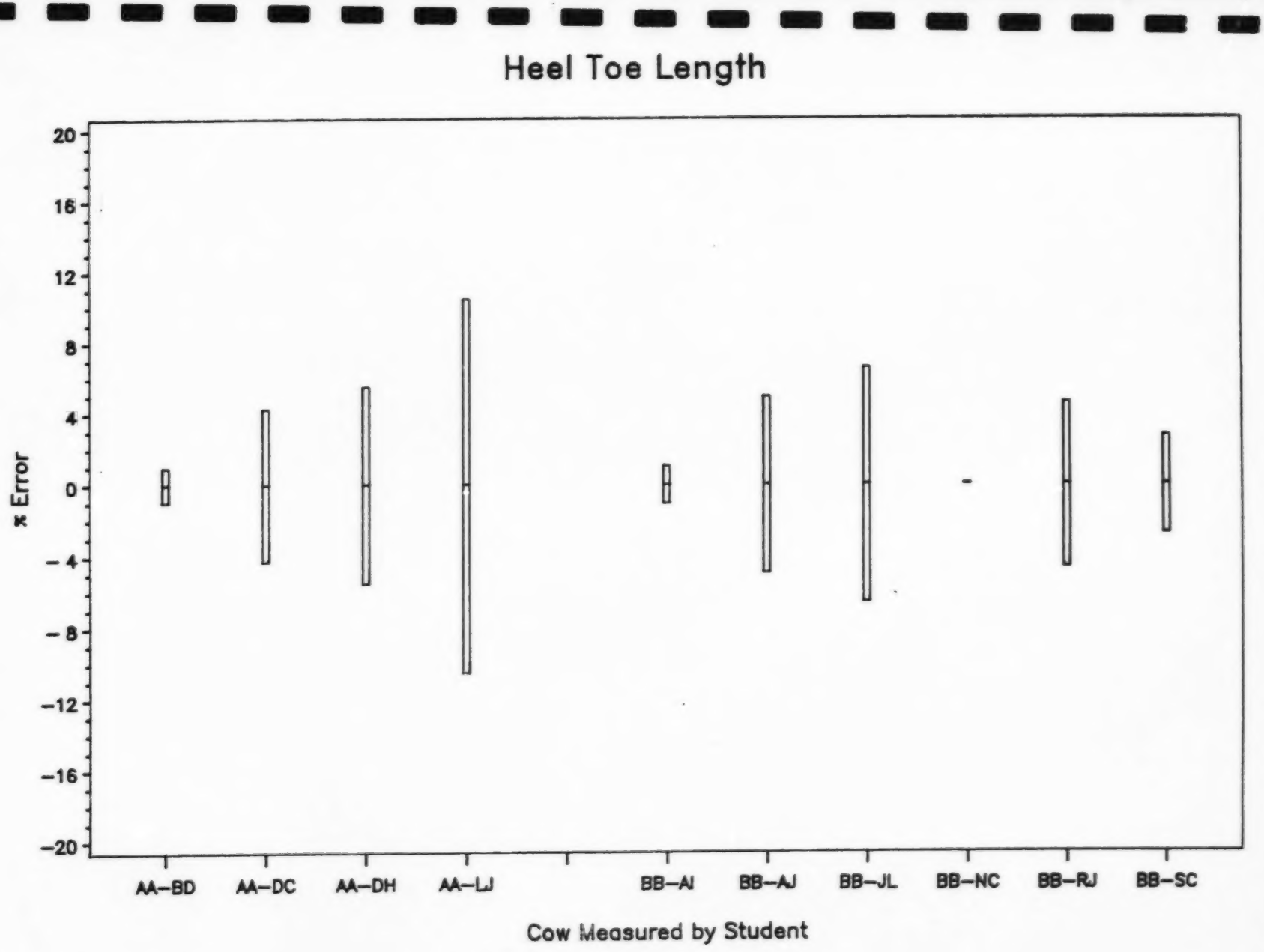
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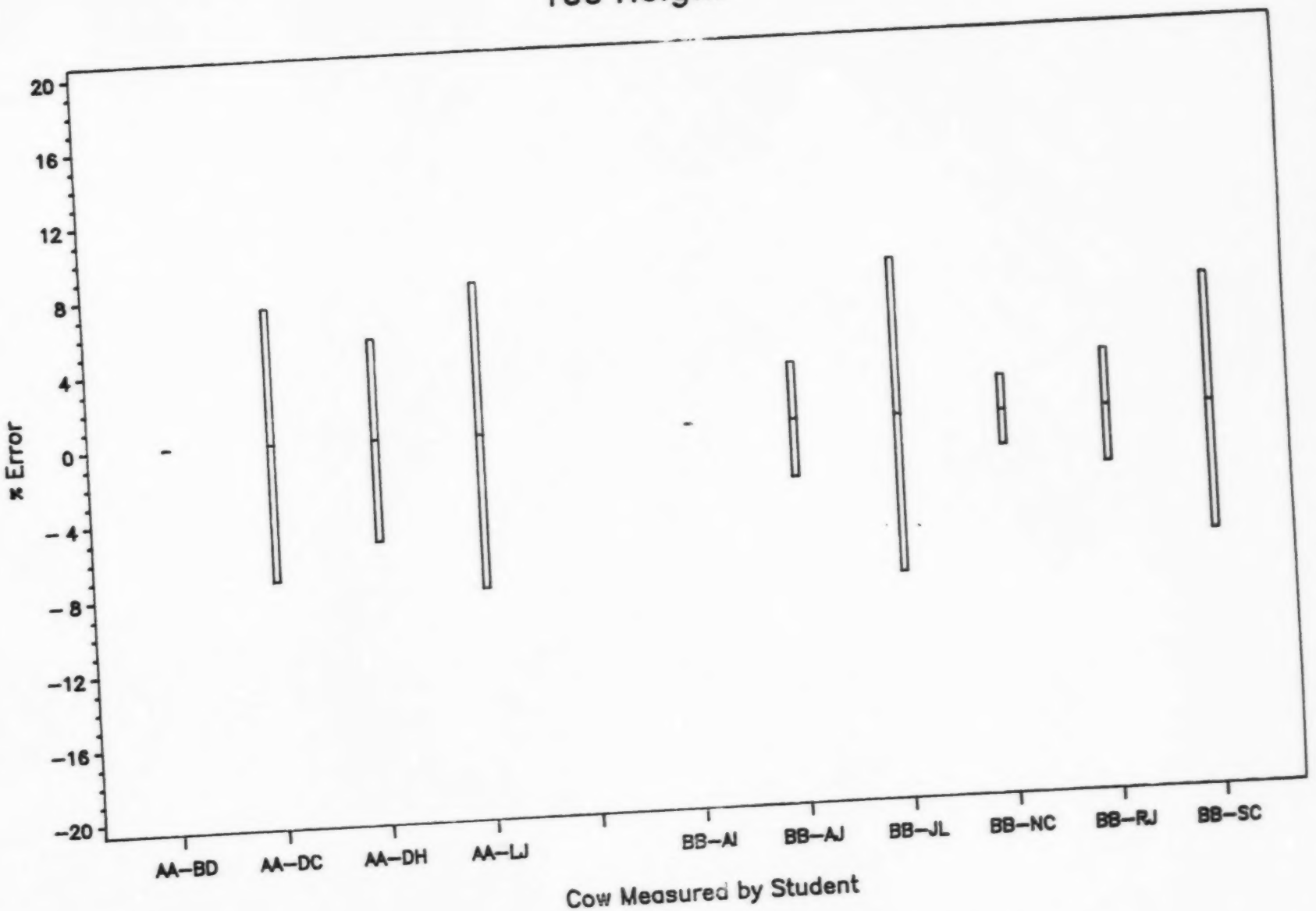
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